MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 1, 2022/2023 (TERM ID 2210)**

## ETM2046 – ANALOG AND DIGITAL COMMUNICATIONS

(RE)

13 FEBRUARY 2023
9.00 a.m – 11.00 a.m
(2 Hours)

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**INSTRUCTIONS TO STUDENT**

1. This question paper consists of 8 pages including cover page and appendices with 4 questions only.

2. Attempt ALL 4 questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the answer booklet provided.

## QUESTION 1

a) Define energy and power signals.

[4 marks]

b) Based on the waveform shown in **Figure Q1**:

(i) Find the trigonometric Fourier series for the order $n$ up to 3.

[10 marks]

(ii) Based on (b)(i), determine the corresponding exponential Fourier series.

[6 marks]

(iii) Sketch the amplitude spectrum for (b)(ii).

[5 marks]

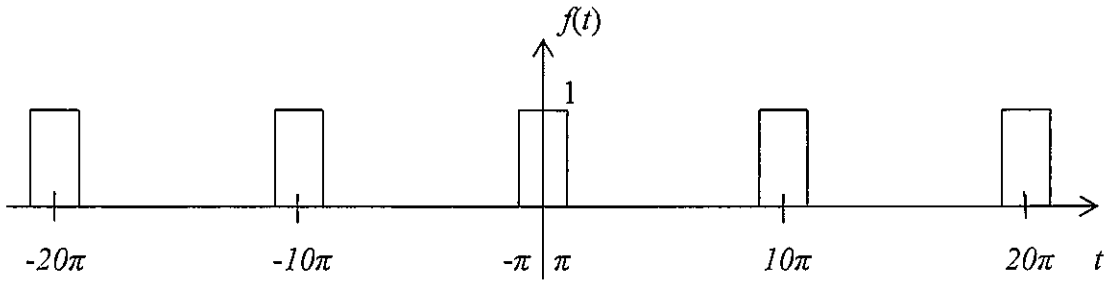


**Figure Q1**

**Continued ....**

## QUESTION 2

a) Briefly describe two advantages and two disadvantages that frequency modulation (FM) has over amplitude modulation (AM)

[8 marks]

b) Consider the following FM signal

$$x(t) = 4\cos\{(2\pi)(10^6 t) + \sin[(2\pi)(10^4 t)]\}$$

(i) Find the average power required to transmit the signal.

[2 marks]

(ii) What is the amount of transmission power that falls in the **sidebands**? The Bessel function table is given below.

[3 marks]

(iii) Find the transmission bandwidth using both Bessel function table and Carson's rule.

[4 marks]

c) Single sideband modulated (SSB) signal can be generated by using filter method or phase shift method.

(i) With the help of suitable diagram, describe the SSB signal generation with both methods.

[5 marks]

(ii) State one advantage and one disadvantage of both method of SSB generation.

[3 marks]

**Continued .....**

## QUESTION 3

a) Given a binary data 0100101. Draw the waveforms of the following signaling formats.

i) Unipolar NRZ

ii) Bipolar RZ

iii) AMI RZ

[6 marks]

b) Discuss the advantages and disadvantages of the signaling formats in part (a), respectively.

[9 marks]

c) Assume that a QPSK signal is used to send data at a rate of 30 Mbits/s over a satellite transponder with a bandwidth of 24 MHz.

(i) If the satellite signal is equalized to have an equivalent raised cosine filter characteristic, what is the rolloff factor required?

[5 marks]

(ii) Could a rolloff factor be found so that a 50 Mbits/s data rate could be supported?

[5 marks]

**Continued .....**

## QUESTION 4

(a) For the set of symbols $S = \{s_k\}$ for $k \in \{1,2,3,4\}$ the probability of occurrence for each symbol in a given message is:

$$\Pr(S = s_1) = \frac{1}{2}, \Pr(S = s_2) = \frac{1}{5}, \Pr(S = s_3) = \frac{1}{4}.$$

(i) Define the term Entropy in the context of information theory.
(ii) Calculate the entropy for the set of symbols $S$.
(iii) Obtain the Shannon-Fano code for the set of symbols $S$.

[2+3+5 marks]

(b) The JPEG standard provides four modes of encoding. Describe each of the encoding modes.

[8 marks]

(c) For the set of symbols given in **Table Q4**, find the Huffman code assuming that the combined probability is always moved to the top.

**Table Q4**

| Symbol | Probability |
|---|---|
| $s_0$ | $\frac{2}{5}$ |
| $s_1$ | $\frac{2}{8}$ |
| $s_2$ | $\frac{1}{6}$ |
| $s_3$ | $\frac{1}{10}$ |
| $s_4$ | 0.083 |

[7 marks]

**Continued .....**

## Appendix I: Table of Bessel Function

| $n$ \ $\beta$ | 0.05 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 | 1.0 | 2.0 | 3.0 | 5.0 | 7.0 | 8.0 | 10.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.999 | 0.998 | 0.990 | 0.978 | 0.938 | 0.881 | 0.765 | 0.224 | -0.260 | -0178 | 0.300 | 0.172 | -0.246 |
| 1 | 0.025 | 0.050 | 0.100 | 0.148 | 0.242 | 0.329 | 0.440 | 0.577 | 0.339 | -0.328 | -0.005 | 0.235 | 0.043 |
| 2 | | 0.001 | 0.005 | 0.011 | 0.031 | 0.059 | 0.115 | 0.353 | 0.486 | 0.047 | -0.301 | -0.113 | 0.255 |
| 3 | | | | 0.001 | 0.003 | 0.007 | 0.020 | 0.129 | 0.309 | 0.365 | -0.168 | -0.291 | 0.058 |
| 4 | | | | | | 0.001 | 0.002 | 0.034 | 0.132 | 0.391 | 0.158 | -0.105 | -0.220 |
| 5 | | | | | | | | 0.007 | 0.043 | 0.261 | 0.348 | 0.186 | -0.234 |
| 6 | | | | | | | | 0.001 | 0.011 | 0.131 | 0.339 | 0.338 | -0.014 |
| 7 | | | | | | | | | 0.003 | 0.053 | 0.234 | 0.321 | 0.217 |
| 8 | | | | | | | | | | 0.018 | 0.128 | 0.223 | 0.318 |
| 9 | | | | | | | | | | 0.006 | 0.059 | 0.126 | 0.292 |
| 10 | | | | | | | | | | 0.001 | 0.024 | 0.061 | 0.208 |
| 11 | | | | | | | | | | | 0.008 | 0.026 | 0.123 |
| 12 | | | | | | | | | | | 0.003 | 0.010 | 0.063 |
| 13 | | | | | | | | | | | 0.001 | 0.003 | 0.029 |
| 14 | | | | | | | | | | | | 0.001 | 0.012 |
| 15 | | | | | | | | | | | | | 0.005 |
| 16 | | | | | | | | | | | | | 0.002 |
| 17 | | | | | | | | | | | | | 0.001 |

## Appendix II: Table of Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}[\cos(A-B) - \cos(A+B)]$$

$$\cos A \cos B = \frac{1}{2}[\cos(A+B) + \cos(A-B)]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta} - e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta} + e^{-j\theta}\right]$$

**Continued...**

## Appendix III: Fourier Transform Pairs

| $x(t)$ | $X(f)$ |
|---|---|
| $\delta(t)$ | $1$ |
| $\delta(t-t_o)$ | $e^{-j2\pi f t_o}$ |
| $1$ | $\delta(f)$ |
| $e^{j2\pi f_o t}$ | $\delta(f-f_o)$ |
| $e^{-at}u(t)$ | $\frac{1}{a+j2\pi f}$, for $a>0$ |
| $e^{at}u(-t)$ | $\frac{1}{a-j2\pi f}$, for $a>0$ |
| $e^{-a\lvert t\rvert}$ | $\frac{2a}{a^2+(2\pi f)^2}$, for $a>0$ |
| $rect\left(\frac{t}{T}\right)$ | $T\text{sinc}(fT)$ |
| $\text{sinc}(2Wt)$ | $\frac{1}{2W}rect\left(\frac{f}{2W}\right)$ |
| $\Delta\left(\frac{t}{T}\right)$ | $\frac{T}{2}\text{sinc}^2\left(\frac{fT}{2}\right)$ |
| $W\text{sinc}^2(Wt)$ | $\Delta\left(\frac{f}{2W}\right)$ |
| $e^{-\pi t^2}$ | $e^{-\pi f^2}$ |
| $\cos(2\pi f_o t)$ | $\frac{1}{2}\delta(f-f_o)+\frac{1}{2}\delta(f+f_o)$ |
| $\sin(2\pi f_o t)$ | $\frac{1}{2j}[\delta(f-f_o)-\delta(f+f_o)]$ |

**Continued...**

## Appendix IV: Fourier Transform Properties

| Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and $a$, $b$, $t_o$ and $f_o$ scalar quantities. | |
|---|---|
| Linearity | $ax_1(t)+bx_2(t) \Leftrightarrow aX_1(f)+bX_2(f)$ |
| Scaling ($a \neq 0$) | $x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$ |
| Time Shifting | $x(t-t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$ |
| Frequency Shifting | $x(t)e^{j2\pi f_o t} \Leftrightarrow X(f-f_o)$ |
| Time Convolution | $x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$ |
| Frequency Convolution | $x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$ |
| Time Differentiation | $\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$ |
| Frequency Differentiation | $(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$ |
| Time Integration | $\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f}+\frac{1}{2}X(0)\delta(f)$ |
| Frequency Integration | $x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$ |

**End of Paper**